#1212

Santa Clara Valley Water District

Storage Capability of the Palo Alto Flood Basin

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1974

March 1974

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SANTA CLARA VALLEY WATER DISTRICT

STORAGE CAPABILITY

OF THE PALO ALTO FLOOD BASIN

by

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March 1974

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INTRODUCTION

Matadero, Adobe and Barron Creeks traverse the City of Palo Alto and furnish outfalls for city storm drainage systems. These creeks historically discharged directly into San Francisco Bay through Mayfield and Charleston Sloughs. As subsidence occurred a levee system was constructed to prevent saltwater flooding from the Bay. The levees created a flood basin, later named the Palo Alto Flood Basin, into which Matadero, Adobe and Barron Creeks discharged. The Basin, which contains approximately 600 acres, is shown on the map on plate 1. A tide gate system was constructed in 1956 to discharge floodwaters from the Basin to the Bay. As subsidence continued the levee system around the Basin and along Matadero, Adobe and Barron Creeks was now no longer adequate to prevent flooding of the existing residential, commercial and industrial development southwesterly of Bayshore Freeway.

In 1964 a report titled "Report on Outfall Channels for Matadero, Adobe, and Barron Creeks" was completed which presented two possible alternative solutions to the flooding problems along the outfall channels of Matadero, Adobe, and Barron Creeks. The first of these was to refine the existing Flood Basin to provide storage of upstream runoff during rising and high tide for discharge during the falling and low portions of the tide cycle. The second alternative investigated was the use of high leveed channels open directly to San Francisco Bay without benefit of a

storage basin or tide gates.

The use of a Flood Basin to store peak runoff for later release to the Bay during periods of low tide was selected to provide the needed flood protection. This provides a lower water surface elevation in the upstream channels with lower levees to provide the necessary flood control protection. The lower water surface elevation also is a direct benefit in that less pumping is required to get local drainage (storm sewer) water into the flood control channels.

The Flood Basin as originally designed required that 440 acres be excavated to an elevation of at least -3.5 feet. Material excavated from the Basin was to be placed on approximately ± 100 acres of land within the Basin adjacent to Bayshore Freeway for potential commercial or industrial development.

Construction was started in 1968 on the flood control improvements and continued as funds were available for construction. The first stage construction was completed in 1970 when the perimeter levees were constructed from Bayshore Freeway on the Adobe-Barron Creek side to a point approximately 1900 feet north of Bayshore Freeway on the Matadero Creek side. The second stage construction was completed in 1972 when flood walls and levees were constructed on Matadero Creek. A third stage will be constructed in the spring of 1974 when the levees on Adobe and Barron Creeks are raised.

The fourth stage is scheduled for completion starting in 1974 and will consist of completing the perimeter levee system. A levee will be constructed along Matadero Creek from the south end of the previously constructed levee to Bayshore Freeway. A levee will also be constructed along the Bayshore Freeway Frontage road from Adobe-Barron creeks to Matadero Creek. A final stage of construction as originally conceived would have been to excavate the 440-acre portion of the Basin and to fill the ±100-acre portion along Bayshore Freeway.

Now that the City of Palo Alto, as part of its General Plan, Open Space Element, has designated the entire 600-acre Flood Basin as a Wetland Preserve,[1] it is desirable to reevaluate the need for the final stage, excavation of the Basin.

[1] See Appendix A

Objective

The objective of this study is to determine if the Palo Alto Flood Basin will provide flood control protection to existing residential, commercial and industrial development if the entire ±600 acre Basin is available for flood storage. The desires of the community to preserve the area within the Basin as a "Wetland Preserve" will be served if no further excavation is required to provide flood control protection.

Design Criteria

In order to determine the existing storing capacity of the Basin the following design criteria were used:

Storage-Elevation Curve - A storage versus elevation curve for the Basin shown on Plate 2, was developed from survey data obtained in October 1972. Plate 2 also notes the elevations of the low points on the existing Basin levees.

Inflow Hydrograph - The 100-year frequency inflow hydrograph which represents inflow into the Basin from Matadero, Adobe, and Barron Creeks is shown on Plate 3. The peak flow rate of 5050 cubic feet per second was obtained by a regional flood frequency method of analysis. The shape of the hydrograph was developed using a Army Corps of Engineers' computer program, titled "Flood Hydrograph".

Tide Cycle - The average four day winter tide cycle was developed by analyzing winter tides recorded at South Bay No. 1 tide gage for the months of December, January, and February during 1967 through 1972. This tide cycle was corrected to reflect the

CONCLUSIONS

The following conclusions are derived from the information gathered and computations made during the course of the investigation described in this report.

1. No further excavation of the floor of the Basin is required if the entire area of 600 acres is available for storage of flood waters.

2. A perimeter levee system around the Basin should be completed by constructing a levee along the Bayshore Frontage Road from Adobe Creek to the City of Palo Alto Municipal Services Center, and around the Municipal Services Center to Matadero Creek. The existing levee on the west side of the Basin should be raised and strengthened from Bayshore Freeway north to the end of the previously constructed levee. The levee should be constructed to elevation +7.0 if imported fill material is used. This includes 2.4 feet of freeboard for wave action and possible future subsidence. If the fill material is obtained by excavation on the Basin floor, then the levees should be raised to elevation +8.0 to account for an additional 1 foot for levee consolidation. The total construction cost is estimated to be $300,000.

RECOMMENDATIONS

The Flood Basin, with raised levees, is an economical and effective means of protecting adjacent areas from flooding. It requires construction of lower levees along Adobe, Barron, and

Matadero Creeks upstream of Bayshore Freeway. Besides offering flood protection, it provides an attractive site for the conservation of wildlife and its natural habitat.

It is therefore recommended that the levees, as shown on Plates 6 and 7, be constructed to elevation +7.0 using imported fill material to provide flood protection to the residential, commercial, and industrial development southerly of Bayshore Freeway.

APPENDIX A

City of Palo Alto

CALIFORNIA
94301

February 9, 1973

PLANNING COMMISSION
Palo Alto, California

Resolution Concerning the Baylands Plan

Members of the Commission:

Attached for your consideration is a Resolution including four recommended actions: 1) rescinding the Three-Finger Lake Plan; 2) designating the Flood Basin as a Wetland Preserve; 3) designating the City-owned lands in San Mateo County as a Marshland Preserve; 4) establishing a Baylands Plant Zone Map.

Also attached is an environmental assessment of the proposed action. Detailed background on these proposals was presented to the Commission on January 17, 1973.

Respectfully submitted,

Naphtali H Knox

NAPHTALI H. KNOX
Planning Director

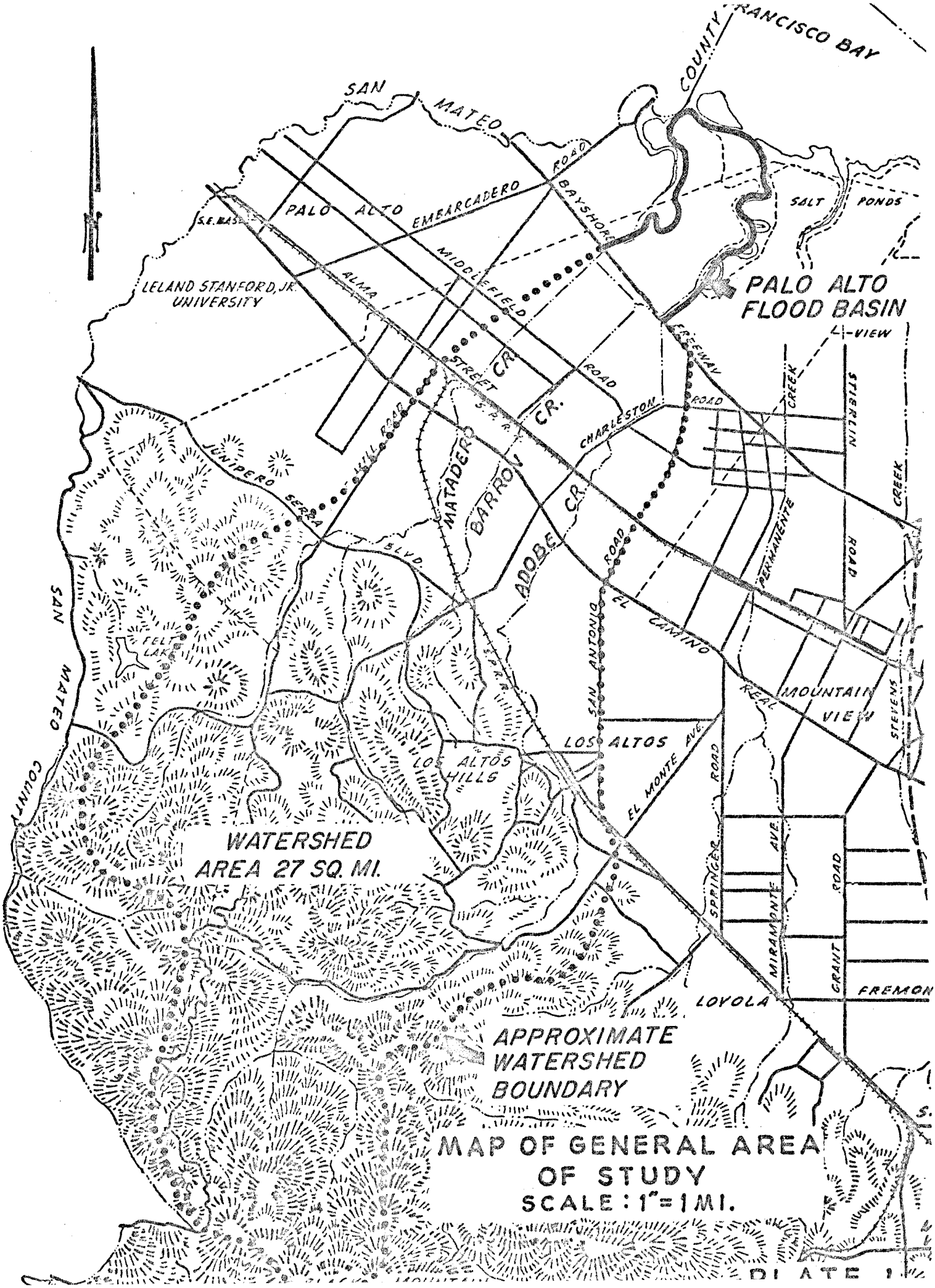
Att.

APPENDIX A

Flood Basin: *

The 600-acre Flood Basin has been designated as a Wetland Preserve. Its primary use is as a flood control facility, but its use as a wetland and wildlife habitat sanctuary is of major importance. It is one of the few remnants left of relatively undisturbed wetland in the Bay Area. Recreation uses here must be compatible with these two major uses and may include hiking, nature walks, and retriever dog training in limited areas. The present plant community provides a permanent habitat and nesting area for several species of waterfowl, shore birds, and mammals; and wintering or resting grounds for many migratory waterfowl and shorebird species which complement the adjoining tidal marsh plant community. The Flood Basin will be enhanced as a wildlife preserve by selective dredging to create island sanctuaries and mounds and by the introduction of compatible salt-tolerant plants to increase the habitat diversity and food supply and variety. This will allow greater use of the wetlands by each species and encourage other species to inhabit the basin.

* City of Palo Alto, Open Space Element of the Palo Alto General Plan, revised on April 23, 1973, Page B-5.


SAN FRANCISCO BAY
COUNTY
SAN MATEO
ROAD
PALO ALTO
EMBARCADERO
BAYSHORE
S.P.R.R.
SALT PONDS
MIDDLEFIELD
ALMA
LELAND STANFORD, JR. UNIVERSITY
PALO ALTO FLOOD BASIN
L-VIEW
FREEWAY
STREET
CR.
ROAD
CREEK
STIERLIN
CHARLESTON
MATADERO
BARRON
CR.
JUNIPERO SERRA
BLVD.
ADOBE
CR.
ROAD
PERMANENTE
CREEK
ROAD
SAN MATEO COUNTY
FELT LAKE
SAN ANTONIO
EL CAMINO
REAL
MOUNTAIN VIEW
STEVENS
LOS ALTOS
LOS ALTOS HILLS
EL MONTE AVE.
ROAD
SPRINGER
AVE
ROAD
MIRAMONTE
GRANT
FREMON
LOYOLA
WATERSHED
AREA 27 SQ. MI.
APPROXIMATE
WATERSHED
BOUNDARY
MAP OF GENERAL AREA
OF STUDY
SCALE: 1"=1 MI.
PLATE 1

tide cycle near Palo Alto by using the Army Corps of Engineers' "Tidal Reference Planes" Chart. The resulting tide cycle as shown on Plate 4, was used in conjunction with the inflow hydrograph to establish the most critical combination of hydrologic events. It should be noted that at low tide periods large volumes of flood water will be released to the Bay, whereas at high tide periods large volumes of flood flows will be stored for later release at the next low tide period. It is evident therefore, that the most severe condition for storing the maximum volume of flood water would have to be determined from several combinations of the time of the peak flow and the tidal cycle. This critical condition would then be considered as the final design criterion.

Design Assumptions

The assumptions made in determining the maximum Basin storage capacity and the time required to empty the Basin are as follows:

1. The 16 automatic tide gates (Armco 60" x 60" Model 107) constructed in 1956 would discharge flood flows efficiently into the Bay. The flap gates will open automatically when the water surface elevation in the Basin is higher than the tidal elevation of the Bay, and will close automatically when the Basin water surface elevation is below the tide elevation.

2. The coefficients of discharge are considered constant irrespective of the change in head. The values used for these coefficients are 2.90 for open channel flow and 0.50 for orifice

flow.

3. The given tide cycle of 75 hours would occur twice in succession in order to determine the time required to reduce the Basin storage to a level which would provide sufficient capacity for subsequent flood flows.

Method of Analysis

A computer program was developed to assist in determining the relationship between storage volume, pool elevation, and discharge through the tide gates against the tide cycle. The program was designed to first compute the discharge through the 16 existing tide gates for six minute time increments using hydraulic theories (open channel flow or orifice flow). This discharge volume was then subtracted from the inflow volume and the difference was added to or subtracted from the volume previously stored in the Basin. This process was repeated for each time interval until the design flood had been discharged from the Basin. The water surface elevation corresponding to the maximum storage is the design elevation for the Basin. The most critical condition of the storage volume in the Basin occurred when the peak inflow of a 100-year flood was coincident with the time that the rising tide was at mean sea level (see Point "A" on Plate 4). Moreover, two initial storage conditions were used in this study and for each condition the 100-year design flood was routed through the Basin and the maximum Basin pool elevations were determined. These initial storage conditions are:

1. Initial pool elevation at -4.80 feet which is the condition that would exist if a flood were to occur when the basin is empty.

2. Initial pool elevation of +4.60 feet which is the condition that would exist if a subsequent flood were to occur immediately following the 100-year design flood.

The purpose for testing these two extreme initial storage conditions was to study the effects on the maximum Basin pool elevations when a subsequent 100-year design flood enters the Basin. Although the chance of having two 100-year floods in quick succession is extremely remote, a lower magnitude flood could occur immediately before or after the design flood, resulting in possible flooding outside of the Basin. Hence it is necessary to determine how soon the flood flows can be discharged into the Bay thereby making sufficient storage available for the subsequent floods. By considering these two 100-year floods in succession, for the condition where the Basin levees are constructed to the design height, the Basin will be able to store flood flows due to any other combination of hydrologic events which are smaller in magnitude.

ENGINEERING EVALUATION OF FLOOD BASIN

The use of a flood basin to store peak runoff for later release to the Bay during periods of low tides allows a lower water surface elevation and therefore lower levees on the upstream channels to provide the necessary flood capacity. This in turn requires less pumping of local drainage water into the flood control channels.

A careful analysis of the effects of time of occurrence and magnitude of the 100-year flood, demonstrated that the most critical condition occurred when the peak flow of a 100-year flood coincided with the time of occurrence of mean sea level on the rising tide of the design tidal cycle. A composite flood hydrograph for the three streams was used as the inflow flood to the Basin. It was also found that the most critical condition existed when a tide peak occurred 4 hours after the inflow peak. The tidal cycle is shown on Plate 4 and the inflow hydrograph of the composite 100-year flood is shown on Plates 3 and 5.

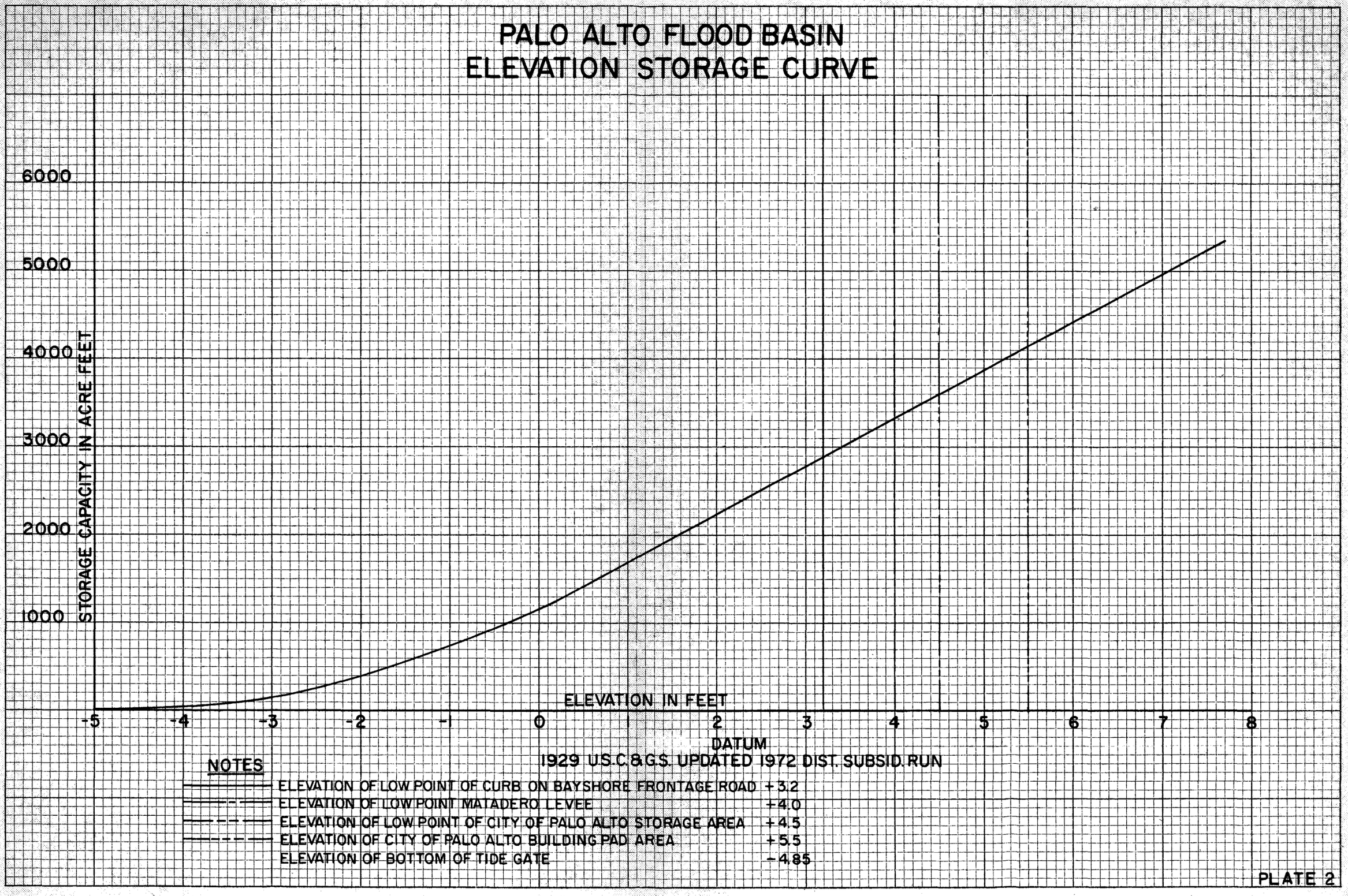
A comparison was made between the maximum Basin storage elevations as obtained by considering the two initial Basin pool elevations. It was found that the maximum pool elevation is +4.60 feet when the 100-year flood is routed through the Basin with the initial pool elevation at -4.80 feet. The maximum pool elevation is +5.96 feet when a subsequent 100-year flood is routed through the Basin immediately following the first flood event.

In this case the initial pool elevation is +4.60.

Study Results

The existing Flood Basin has a limited storage capacity defined by the topography and the area of the Basin. The maximum storage elevation of the Basin was determined (Plate 5) using the initial storage elevation of -4.8 and the existing tidal gates. The storage volume corresponding to this elevation (+4.60) is 3,596 acre feet. It can be seen from Plates 2, 6, and 7 that in order to store 3,596 acre feet of water, portions of levees surrounding the Basin would have to be raised to a minimum elevation +7.0 including 2.4 feet of freeboard to account for wave action and future subsidence. Additional levee height will be required to account for future levee consolidation. This additional height will vary from 0 to 1 foot depending upon the type of material used to construct the levees (zero for imported material, 1 foot for material excavated from the Basin floor). Furthermore, the results show that the Basin storage depth will be increased by 1.3 feet if the effective initial storage elevation is +4.60 just prior to the occurrence of another 100-year design flood.

PALO ALTO FLOOD BASIN
ELEVATION STORAGE CURVE



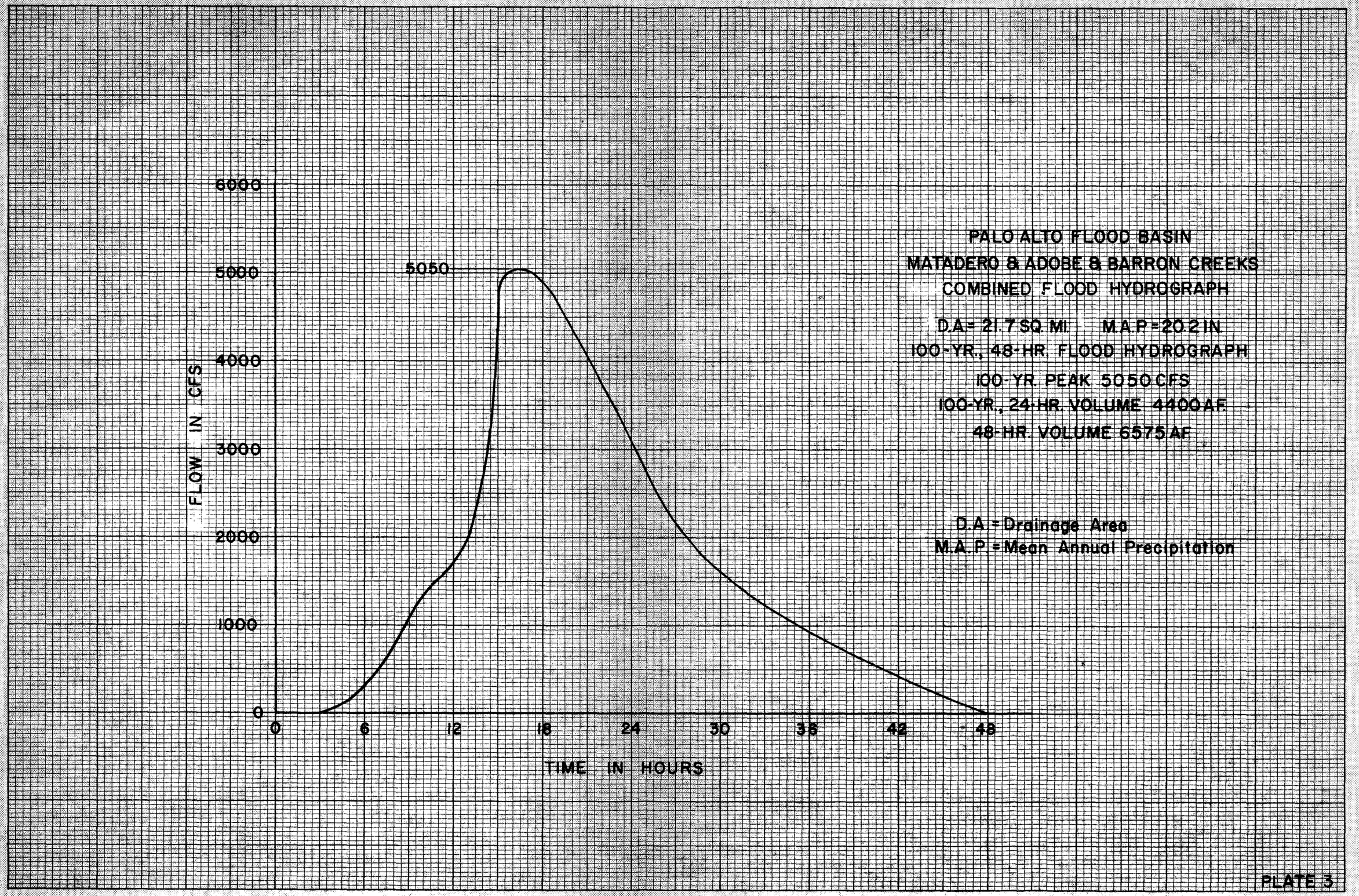
DATUM
1929 U.S.C.&G.S. UPDATED 1972 DIST. SUBSID. RUN

NOTES

- ELEVATION OF LOW POINT OF CURB ON BAYSHORE FRONTAGE ROAD +3.2
- ELEVATION OF LOW POINT MATADERO LEVEE +4.0
- ELEVATION OF LOW POINT OF CITY OF PALO ALTO STORAGE AREA +4.5
- ELEVATION OF CITY OF PALO ALTO BUILDING PAD AREA +5.5
- ELEVATION OF BOTTOM OF TIDE GATE -4.85

PLATE 2

KEUFFEL & ESSER CO.
MADE IN U.S.A.
10 X 10 TO THE INCH
10 X 15 INCHES
K&E 10 X 10 TO THE INCH 47 0703



PALO ALTO FLOOD BASIN
MATADERO & ADOBE & BARRON CREEKS
COMBINED FLOOD HYDROGRAPH

D.A.= 21.7 SQ. MI. M.A.P.=20.2 IN.
100-YR., 48-HR. FLOOD HYDROGRAPH
100-YR. PEAK 5050 CFS
100-YR., 24-HR. VOLUME 4400 AF.
48-HR. VOLUME 6575 AF.

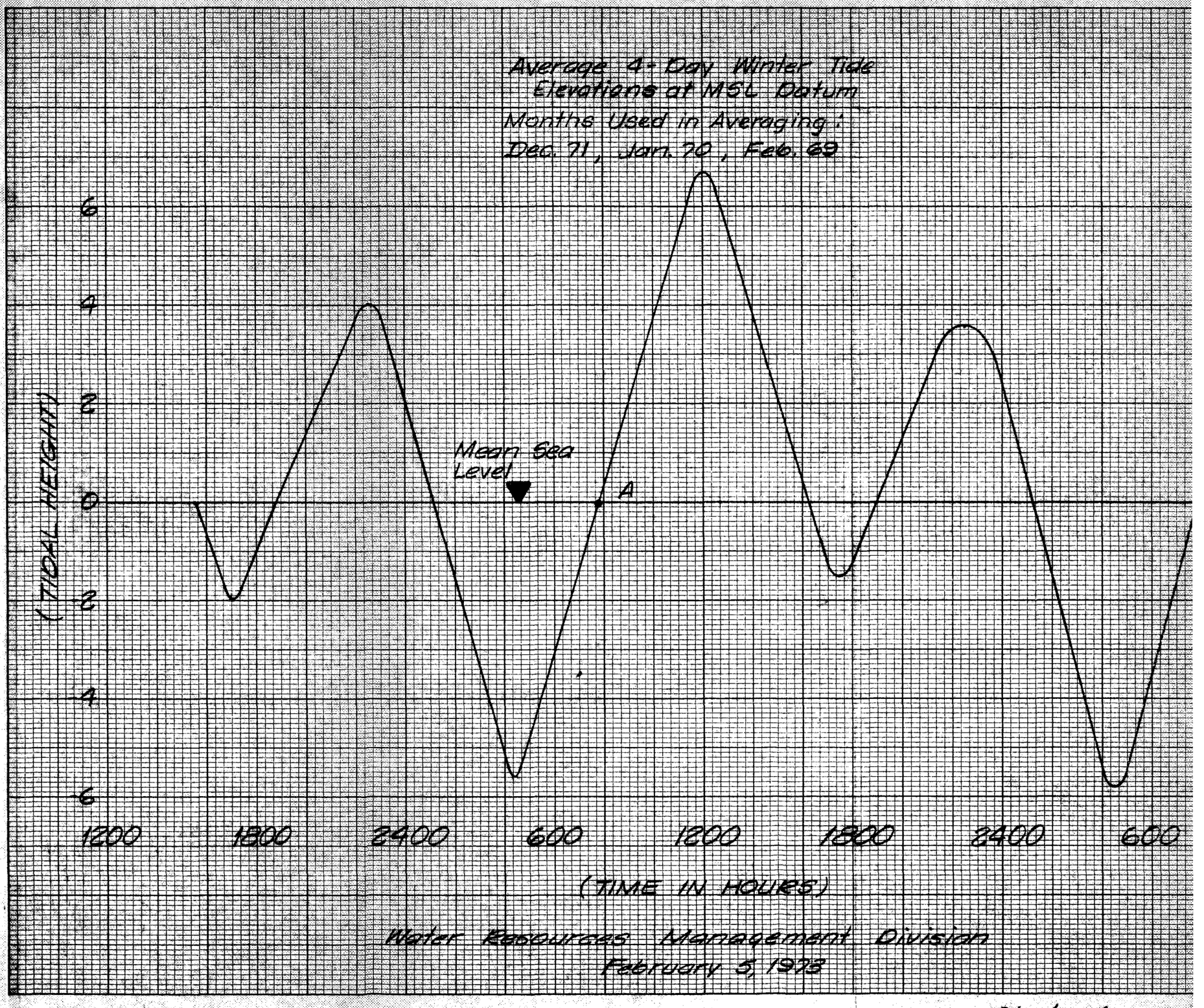
D.A = Drainage Area
M.A.P. = Mean Annual Precipitation

PLATE 3

K+E 10 X 10 INCHES 359 1813
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 TO 1 13 X 20 CM. TO THE INCH

Average 4-Day Winter Tide Elevations at MSL Datum

Months Used in Averaging:
Dec. 71, Jan. 70, Feb. 69



Water Resources Management Division
February 5, 1973

Plate 4

KEY

BASIN POOL ELEVATION WITH I.S. ELEV. = +4.6

BASIN POOL ELEVATION WITH I.S. ELEV. = -4.8

OUTFLOW WITH I.S. ELEV. = +4.6

OUTFLOW WITH I.S. ELEV. = -4.8

I.S. = INITIAL STORAGE

INFLOW HYDROGRAPH SEE PLATE 3

EL. +5.96

EL. = +4.60

MEAN SEA LEVEL

ELEVATION IN FEET

DISCHARGE IN 1000 CFS

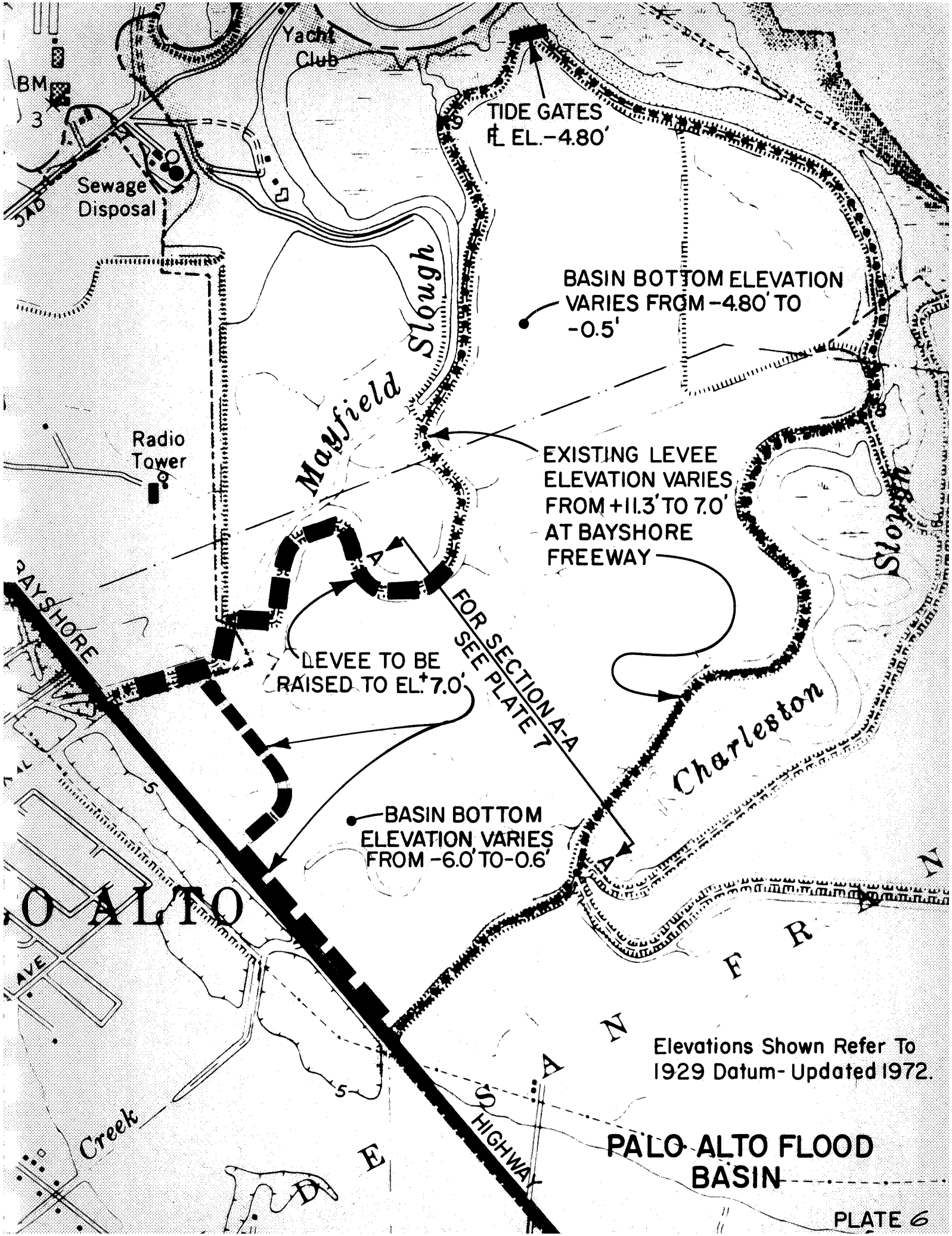
ELEVATION IN FEET

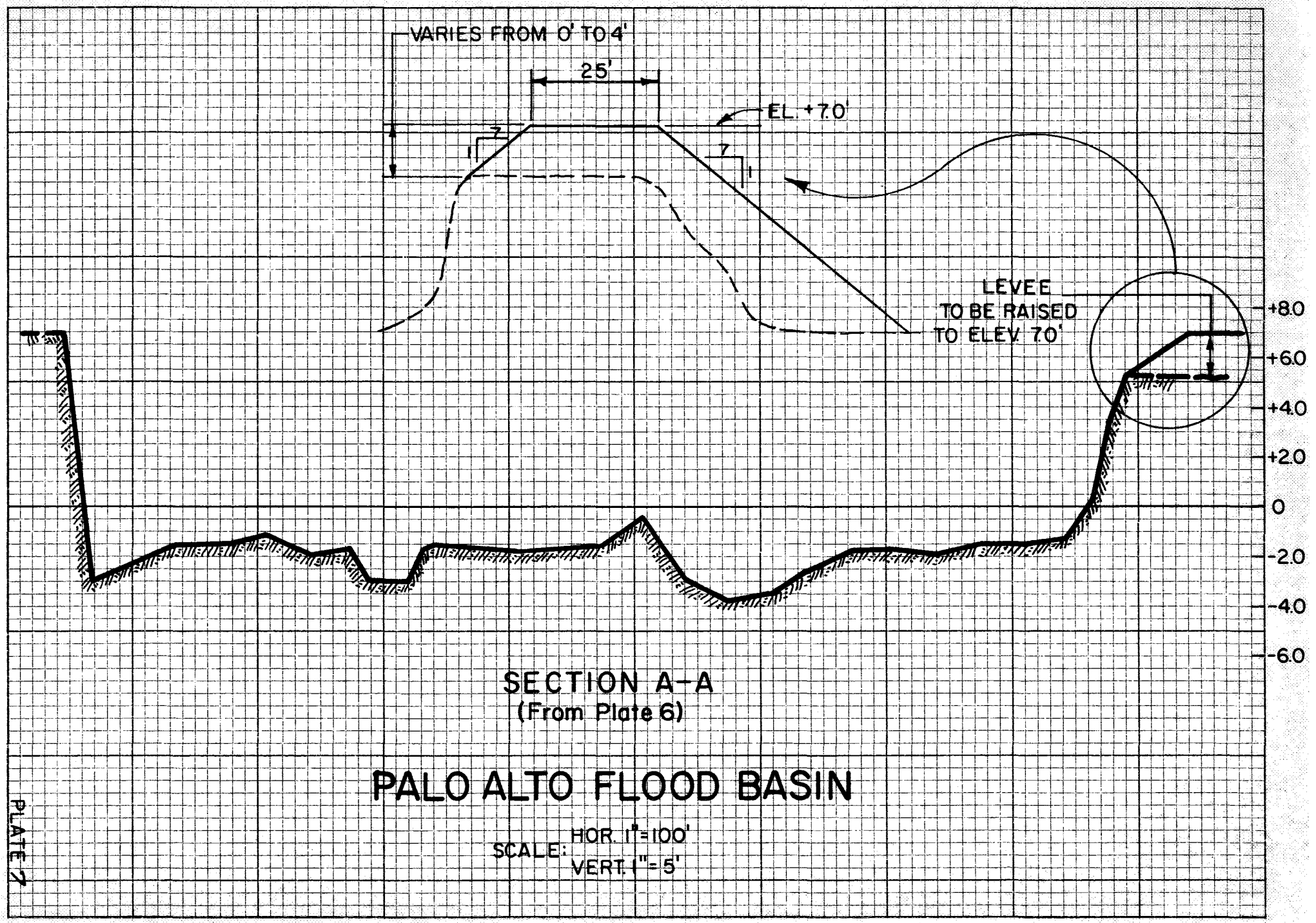
TIME IN HOURS

TWO CONDITIONS OF FLOOD BASIN OPERATION WITH INFLOW PEAK MATCHING
MEAN SEA LEVEL ON THE RISING TIDE (Point "A" Plate 4)

PLATE 5

KEUFFEL & ESSER CO. MADE IN U.S.A.
K+E (10 X 10 INCHES)
5 X 5 TO THE INCH
47 1373


Yacht Club
BM 3
TIDE GATES
EL. -4.80'
Sewage Disposal
BASIN BOTTOM ELEVATION VARIES FROM -4.80' TO -0.5'
Mayfield Slough
Radio Tower
EXISTING LEVEE ELEVATION VARIES FROM +11.3' TO 7.0' AT BAYSHORE FREEWAY
BAYSHORE
LEVEE TO BE RAISED TO EL. +7.0'
FOR SECTION A-A SEE PLATE 7
Charleston Slough
BASIN BOTTOM ELEVATION VARIES FROM -6.0' TO -0.6'
PALO ALTO
SAN FRANCISCO BAY
Elevations Shown Refer To 1929 Datum- Updated 1972.
Creek
HIGHWAY
PALO ALTO FLOOD BASIN
PLATE 6



SECTION A-A
(From Plate 6)

PALO ALTO FLOOD BASIN

SCALE: HOR. 1" = 100'
VERT. 1" = 5'

PLATE 7